WEST AFRICAN CACAO RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 37

TAFO, GOLD COAST.

COMMONWEALTH MYCOLOGICAL INSTITUTE
JUL 1955

WEST AFRICAN COCOA RESEARCH INSTITUTE
TAFO

THIRTY-SEVENTH QUARTERLY REPORT : JANUARY-MARCH, 1955

SENIOR STAFF

Director	:	(vacant)
Deputy Director	:	A. Pickles (Acting Director)
Maintenance Engineer	:	C. Alderson (on leave 30th March)
Secretary	:	G. H. Neal

TAFO STATION

Division of Entomology	:	H. R. Mapother F. Raw D. J. Taylor P. B. Cornwell F. E. Decker (returned 28th Feb.)
Division of Pathology	:	W. T. Dale T. W. Tinsley (on leave 16th March) A. L. Wharton G. Usher (on leave 11th Feb.)
Division of Botany	:	J. F. Archibald (on leave 16th March) H. H. Rogers R. Knight (on leave 23rd March) A. D. McKelvie
Division of Soil Science and Chemistry	:	S. N. Adams Miss E. M. Holden
Division of Agronomy	:	R. J. Benstead R. Wickens
Station Manager	:	S. E. N. Kwafo

IBADAN SUBSTATION

Acting Officer-in-Charge	:	J. Nicol
Entomologist	:	R. G. Donald
Pathologists	:	R. M. Lister J. M. Thresh

STAFF .../

STAFF MATTERS

Dr. T.W. Tinsley, Mr. R. Knight and Major C. Alderson went on final home leave in March prior to leaving the Institute's service.

The Acting Director, accompanied by Mr. H.H. Rogers, Plant Breeder, paid a brief visit to England in February in order to attend a meeting at the Colonial Office of the Cocoa Research Sub-Committee of the Committee for Colonial Agricultural, Animal Health and Forestry Research. Visits were also paid to Bournville, Slough, Rothamsted Experimental Station and Cambridge University on business concerning the work of the Institute. A ten-day visit to the cacao growing areas of Sierra Leone was paid by Mr. D.J. Taylor in February, to study the incidence of capsid pests of cacao; towards the end of March Dr. F. Raw visited the Institute's Substation at Ibadan to examine symptoms of severe capsid damage in Nigeria; and Mr. R.J. Benstead visited Eastern Nigeria during March to examine the possibility of expanding the cacao industry.

MANAGING COMMITTEE

The Technical Sub-Committee met at Ibadan on the 6th January, 1955. The Managing Committee met at Tafo for its sixteenth meeting on 24th February, 1955.

VISITORS

The Institute continued to receive a considerable number of visitors. These included Mr. F.C. Bawden and Dr. Herbert Greene of Rothamsted Experimental Station, Mr. and Mrs. John Cadbury, Lord Harlech, the Chairman and two senior officials of the Gold Coast Cocoa Marketing Board, representatives of the chocolate industries of America, Switzerland and Germany, and Government officials from the United Kingdom, Nigeria and the Gold Coast. Mr. J. Lamb, Director-Designate of the Institute also visited us for ten days in February. The Governor, Prime Minister, and Minister of Agriculture, Western Region, Nigeria, visited the Substation; also Messrs. Bawden and Cadbury, and representatives of the American cocoa trade.

MANAGEMENT AND MAINTENANCE

The former Maintenance Division has been completely merged with Station Management, under the Station Manager. A responsible officer has been engaged to assist in running the workshop and waterworks. This has already enabled several unserviceable vehicles to be put into use. A comparable officer has been appointed to help with building construction and maintenance work. The new bungalow, the Capsid Research Laboratory, the Rest-House extension and the store at the Substation (see Thirty-sixth Quarterly Report) are all either complete or virtually so.

The average daily consumption of water fell from over 25,000 gallons in January and February to under 20,000 gallons in March. This was largely attributable to a decline with the onset of wetter weather in the amount of water taken from the standpipes by people from Tafo town. During dry months consumption very closely approaches the capacity of the plant.

CROP DELIVERY

Cacao harvesting for the season was completed during the quarter. The final figures indicated a yield of 19.4 per cent. less than that for last season; although the recovery rate was higher (11.2 pods per lb. of dry cocoa compared with 11.7) and the percentage of discarded pods was lower (8.9 per cent. as against 11.0 per cent. for last season). The harvest was characterised by an early peak in September followed by a sharp decline.

SWOLLEN SHOOT DISEASE INCIDENCE

Following a period of flushing in February there was a rise in the number of infected trees discovered on the Square Mile, due to easier recognition of symptoms in the flush leaves: two trees were removed from the Introductions area, one from the First Clonal Trial and fifteen from the Clone Collection. On the Old Station seven infected trees were discovered in the Pollarded Plot, twenty in the First Progeny Trial and twenty-one in the Routine Plantings. The following Table shows the number of infected trees diagnosed at Tafo and on the out-stations

	Jan.	Feb.	March	Total
Old Station	58	37	58	153
Square Mile	85	203	88	376
Adonkwanta	6	10	-	16
Akwadum	-	-	1	1
Nankese	-	-	-	-
Kukua	-	-	3	3
Koransang	-	-	-	-

OUT-STATIONS

There was a very marked drought effect at all stations except Adonkwanta, but there has been a full recovery after the February rains. Capsid damage has been light.

IMPROVED PLANTING MATERIAL

Further F.2 Upper Amazon pods were despatched to Nigeria, bringing the total for the year 1954/55 to 6224.

RAINFALL

The monthly rainfall during the quarter at each of the Institute's observation stations in the Gold Coast is given below.

Station .../

Station	Rainfall in inches				Wet days			
	Jan.	Feb.	Mar.	Total	Jan.	Feb.	Mar.	Total
Tafo	0.58	4.94	7.71	13.23	4	9	16	29
" 16-year mean	1.63	3.76	5.96	11.35	3.6	7.1	11.5	22.2
Adonkwanta	-	3.81	10.47	14.28	-	5	9	14
Akwadum	0.43	2.73	7.09	10.25	4	6	11	21
Nankese	0.06	2.52	6.95	9.53	1	6	12	19
Kukua	-	3.26	4.34	7.60	-	6	10	16
Koransang	0.39	2.26	5.86	8.51	2	5	8	13

RESEARCH WORK

Following the pattern laid down in the Thirty-sixth Quarterly Report, the accounts of research work which follow are arranged in the order set out in the approved Research Programme. If a project is not mentioned there is nothing new to report on it, due usually to the nature of the work or the absence on leave of the officer responsible.

TAFO STATION

1. VIRUS RESEARCH

(a) Host Range of Cacao Viruses

A widespread survey of the distribution of *Adansonia digitata* L. in Gold Coast cacao areas is being carried out with the help of the Department of Agriculture. This has made particularly good progress in Ashanti, where almost every village has at least one tree, and some as many as thirty. A total of 189 trees have been examined but no virus infections have yet been diagnosed. Though *Adansonia* is quite common in the Gold Coast, particularly in the Northern Territories, it appears to have been introduced from the Sudan-Savannah zone by migrating Northern Tribesmen, who value it as a source of food and medicine. Whether the virus found in *Adansonia* was brought into the country along with this tree or spread into it from some native host, and the possible connection between viruses of *Adansonia* and cacao (see Section 1c) are matters for speculation. It is hoped that further work will elucidate these points.

An attempt is being made to relate the distribution of virus-infected *Cola chlamydantha* K. Schum. to outbreaks of swollen shoot disease in the Western Province. Six virus strains have been isolated from *C. chlamydantha* trees growing in widely separated localities and their symptoms in cacao seedlings are being studied. All produce severe leaf symptoms and swellings in cacao, and similarities have been noticed to virus strains isolated from mature cacao in the Western Province. Protection tests between isolates from *C. chlamydantha* and some of those from cacao are in progress, but no results are yet available.

In .../

In laboratory tests, twenty-five species of Tiliales have proved susceptible to infection with one or more of the cacao virus isolates maintained at Tafo. They are:-

Corchorus aestuans L., C. olitorius L., C. tridens L., C. triloculars L. (Tiliaceae); Cola chlamydantha K. Schum., C. gigantea var. glabrescens Brenan & Keay, C. lateritea var. maclaudi Brenan & Keay, Erythropsis barteri (Mast.) Ridley, *Herrania balaensis Preuss., *H. spp. "A" and "B" (indet.), Pterygota macrocarpa K. Schum., Sterculia rhinopetala K. Schum., S. setigera Del., S. tragacantha Lindl., *Theobroma angustifolia DC., *T. bicolor Humb. & Bonpl., *T. grandiflora K. Schum., *T. macrocarpa Mart., *T. obovata Bern., *T. speciosa Spreng. (Sterculiaceae); Adansonia digitata L., Bombax buonopozense P. Beauv., *B. malabaricum DC., Ceiba pentandra Gaertn. (Bombacaceae).

The susceptibility of Guazuma ulmifolia Lam. (Sterculiaceae) reported in the 1953/54 Annual Report has not been confirmed, and is now considered doubtful.

(b) Insect Transmission Studies - New Juaben Virus

Attempts to find out whether the virus undergoes a short latent period in the vector (Pseudococcus njalensis Laing) were inconclusive, but young adults proved capable of acquiring and transmitting it in as little as 5 hours.

Two experiments have been completed, using young adults of P. njalensis, to elucidate the effect of vector numbers on infection rate. These differed only in that the source plants used in the second were 5 or 6 weeks old, while those in the first were a few weeks older. The mealybugs were given 18-hour pre-infection-starving, 24-hour infection-feeding and 24-hour test-feeding periods, and the treatments were 1, 2, 4, 6, 8 or 10 insects, selected at random, per test bean. All the vectors used in any replication were fed on the same source plant. For the first experiment the infection rates were 18, 30, 60, 61, 73 and 92%, and for the second 44, 53, 88, 92, 96 and 97% respectively. At the time these experiments were carried out it was sometimes difficult to obtain pods that were not over-ripe, so some test beans may have been slightly wilted and thus difficult to infect, even using many vectors. The results indicate that under conditions presumed to be optimum an Amelonado bean is almost certain to be infected by ten young adults of P. njalensis. They also confirm the observations of Posnette & Robertson (Ann. appl. Biol., 37, p. 363) regarding the absence of a "mass-action" effect with larger numbers of vectors. In other words, individual mealybugs do not inject sub-minimal doses of virus which can accumulate to produce infection when groups of these insects are used.

Mealybugs at three stages of maturity were compared: first- and second-instar nymphs ("crawlers"), third-instar nymphs, and young adults. Three insects per test bean were employed, with all other factors at the presumed optimum. Infection rates for the stages, in the order mentioned above, were 68, 74 and 75% (based on 72 replications). This result does not support the earlier suggestion that comparable infection rates are obtainable with ten adults or thirty crawlers.

*Exotic species.

There .../

There are, of course, greater chances of non-feeding crawlers being selected and of feeding ones being damaged during manipulation, if the operator is relatively unskilled; which may have accounted for the earlier belief. On the other hand, it must be recorded that in the present experiment most of the crawlers were probably second-instar nymphs, as there was a tendency to select the bigger ones for ease of handling.

A few preliminary trials have been made to compare the efficiency of different vector species. Ferrisia virgata (Ckll.) proved to be much inferior to P. njalensis, but seems unsuited to source feeding on green apices within paper cones, because of the larger amount of wax produced. The insects became tangled together and few settled. Planococcus citri (Risso) seems to have the same drawback; so it may be difficult to obtain a fair comparison between these species and P. njalensis, which feeds poorly on leaves compared with the other two.

(c) Classification of Viruses and Virus Strains

Studies on the inter-relationships of isolates in the insectaries at Tafo, using protection tests and symptomatology, have made good progress; but much remains to be done.

So far, no Nigerian isolate has shown relationship to any cacao virus from elsewhere. Isolates from Olanla and Ilesha are related, but distinct from Offa Igbo isolates. From their symptoms, the Asalu and Alaparun strains appear distinct; though neither produces swellings, their leaf symptoms are quite different. Strains from Mampong, Nkawkaw, Pamen, Nsaba and Bisa, in the Eastern Province of the Gold Coast, all seem distinct. An isolate from Dawa belongs to the New Juaben complex, which is also represented by isolates from Konongo in Ashanti and Kongodia in the Ivory Coast; where there are at least two other apparently distinct viruses, those from Appompromou and Yakasse. The Bosumtwi, Sedi Nkawe and Okerikrom isolates from Ashanti are all, on present evidence, distinct. Twelve isolates from the Western Province of the Gold Coast are under investigation; no protection has yet been demonstrated, in spite of symptom similarities between some isolates. An isolate from Peki in the Trans-Volta area resembles the Bisa strain, though that gives bigger swellings; no protection tests have been made. The Kpeve (mottle-leaf) virus from British Mandated Togoland, one of those which gives no swellings, is very distinctive. It is most like the Alaparun (Nigeria) strain and certain Adansonia isolates, but has been tested against the former with negative results. The Adansonia isolate AD.7 is unrelated to the Mampong and New Juaben cacao strains.

(d) Attempted Mechanical Transmission

Further attempts at mechanical transmission of swollen shoot virus have been made using very dilute leaf extracts, as Fulton (Phytopathology, 42, 413, 1952) found that rose-mosaic virus could be transmitted mechanically with dilute extracts but not with undiluted juice. Infected seedling-cacao leaves were ground in a large volume of pH7 phosphate buffer with sodium sulphite present, and the extract used to inoculate various plants, including cucumber and cowpea. There was no evidence that virus had been transmitted.

(e) .../

(e) Effect of Nutrition on Infection with the New Juaben Virus

Two further water-culture experiments (V and VI) have been started. All plants are receiving at least the minimum requirement of the three major elements - nitrogen (N), phosphorus (P) and potassium (K) - to keep them growing and free from undue defoliation. It is hoped to continue these experiments for at least six months.

Experiment V includes eight nutritional treatments - NPK, NP, NK, PK, N, P, K and nil (apart from the minimum requirement) - applied to both healthy and infected plants. Symptom recording is restricted to "flush" and "hardened flush" leaves. Additional records, such as the weights of the plants at regular intervals and chemical analyses, are being kept.

Experiment VI is an investigation of the effect of N at three levels on the incidence of root swellings. It is hoped to study, also, the effect of the treatments on availability of the virus to vectors, and on the susceptibility of control plants to infection at the end of the experiment.

(f) Chemical Detection of Virus Infection

Symptomless cacao trees on the Old Station which gave a high score in the colour test in September, 1954, suggesting that they might be infected, but which have still shown no symptoms, are now being re-tested to see if they are still giving the same result. "Back-tests" by grafting were made from these trees 5 months ago and none of the test plants have shown symptoms of infection. On the other hand, some trees which originally gave a low colour-test value have since shown symptoms. It is of interest to try and find out what factors other than infection with swollen-shoot virus are likely to cause a high clour-test score. Since a high score is associated with a high "tannin" content, factors which cause an increased "tannin" concentration are being investigated. In this connection material from an experiment in which seedlings were grown in light or shade is being analysed. Preliminary results indicate that seedlings grown in the light have a higher content of aqueous acetone soluble "tannin" (expressed on a dry-weight basis) than shaded seedlings.

Mature trees on the Old Station that are reported as showing symptoms of infection are sampled for colour testing before being cut out. Material from these trees is used for grafts as a check on this method of "back-testing".

Work has continued on the separation and estimation of the "tannin" constituents of healthy mature and flush leaves, and of mature leaves from trees infected with swollen-shoot. The substance, not yet identified, responsible for giving the red colour in the test is present in healthy leaves, though at a much lower concentration than in diseased.

Routine testing of Trinidad Introductions is being continued.

(g) .../

(g) Morbid Histology of Infected Cacao

This study has now been completed and a full account is to be published soon. The main point that has been established is that symptoms in the mature leaf result from failure of young virus-infected tissues to differentiate, so that some juvenile characters persist. Transverse sections of infected leaves, under magnification, revealed an absence of spaces in the spongy mesophyll of chlorotic areas.

Resistance to the New Juaben Cacao Virus

This project is included in the Research Programme for 1955/56.

Some of the Iquitos plants that were colonised as beans with forty infective "crawlers" of Pseudococcus njalensis (see 35th Quarterly Report) have shown a degree of resistance to infection. The percentages of plants amongst the various progenies and their controls which gave no evidence of infection (either visually or by "back-tests") within seven months of infestation were as follows :-

T17/1131 x 1220 - (59); T17/1070 x 447 - (49);
T17/1131 x 1159 - (46); T17/1131 x 1157 - 39;
T17/1072 x 433 - 23; T17/1072 x 358 - 21;
T17/1070 x 1219 - 13; T17/1072 x 357 - 0;
controls (total) - 10.

The brackets around certain percentages indicate trials in which some control plants failed to become infected, which should not have occurred with forty crawlers per bean; so these high figures may not be as satisfactory as would appear. Different operators participated in the infestation of beans, and differences in their dexterity revealed by these failures were not fully appreciated at the time.

At seven months old, each apparently uninfected plant was colonised for one day with 200 infective crawlers. It is already apparent that few (if any) will escape infection.

Progenies tested using the "twinning" method (see 36th Quarterly Report) are now developing symptoms, two months after infestation. The incidence of infected plants already apparent indicates that the number of infective crawlers (150) used per plant may have been too great.

So far, it is not clear if seedlings derived from the same pod show segregation for resistance; the proportions failing to become infected after testing may reflect either a common low level of resistance or a mixture of relatively resistant and susceptible types. By producing a number of clonal plants from each uninfested "twin" and carrying out appropriate infection tests with vectors it should be possible to elucidate this fundamental point.

2. MEALYBUG STUDIES

(a) Movement of Mealybugs in the Canopy

Experiments were started to investigate the movement of mealybugs on individual cacao trees.

Daily .../

Daily examination of pieces of cacao twig attached to cacao trees at positions varying from ground level to the tips of the canopy branches has shown that first-instar nymphs are the most mobile stage, and that movement is mainly confined to the canopy branches.

(b) Aerial Dispersal Studies

The studies described in the previous report have been continued. A study is also being made of the relationship between catches of airborne mealybugs on adhesive traps and the proximity of the traps to trees of different population densities. In addition, 100 adhesive traps are being used to study the wind dispersal of mealybugs in an area where the cacao has been removed but where forest trees remain standing.

In experiments so far conducted to study the aerial movement of vectors, adhesive and seedling traps have been used throughout. The low mean wind speeds of about 1 and 0.1 m.p.h. in cacao clearings and in the canopy, respectively, may be largely responsible for the small numbers of insects recorded. Preparations are being made for the use of suction traps to sample large quantities of air and thereby provide more reliable measures of insect abundance.

(c) Variation in Mealybug Populations

The survey to compare populations of mealybugs, associated ants, predators and parasites on cacao under different cultural conditions has been completed. Much new information has been obtained on the ecology of Pseudococcus njalensis, particularly in relation to the factors influencing population variations.

(d) Biological Control of Mealybugs

Introductions

The species of parasite which was originally designated "M" by the Commonwealth Institute of Biological Control has now been named Acroaspidia myrmicoides Comp. and Zinna (ined.). It has reproduced successfully in Pseudococcus njalensis, Ferrisia virgata and Phenacoccus madeiriensis Green. Shipments of Scymnus sordidus Horn, a Coccinellid, have been arriving from California since February. This ladybird beetle has been reared successfully on P. njalensis, P. brevipes Ckll. and Ferrisia virgata.

Releases

A total of 75,184 parasites, made up as follows, has been liberated in the Old Station during the quarter :-

35,171	Pseudaphycus angelicus How.
36,000	Pseudaphycus mundus Gahan
4,013	Anagyrus pseudococci Gir.

2,927 Scymnus sordidus have also been released in the Old Station.

Recoveries .../

Recoveries

The specimens of Pseudaphycus sp. reared from Pseudococcus njalensis collected at Bunso and Koransang, and mentioned in a previous Quarterly Report, have been determined by the Commonwealth Institute of Entomology as a variety of P. angelicus.

No further recoveries have been made.

3. STUDIES ON BLACK-POD DISEASE

(a) Fungicide Control Trials

Harvesting and spraying treatments in Trials I and II at Bunso Plantations continued during the quarter, though both crop and black-pod disease (Phytophthora palmivora Butl.) were negligible. In the absence of losses due to fungus diseases at this time of year the serious depredations of rodents are worth recording: out of a total of 4399 pods harvested from the 1728 trees in Trial I, 3423 were completely destroyed by rats and squirrels.

Most of the figures from both trials for the entire 1954/55 crop season have been analysed during the quarter. The main points are summarised below, fuller details being included in the Annual Report.

TRIAL I

As in the 1953/54 season (see 35th Quarterly Report) weekly harvested plots yielded more pods than those receiving the monthly harvesting treatment, accounting for 57.7% of the total. The effect was less striking in Trial II, but it was confirmed in two trials undertaken by the Division of Agronomy (see Section 5 - Frequency of Picking Experiments). These increases do not seem to have been fortuitous, but the reason for them is obscure. There is no evidence that they were due to a stimulus from the frequent removal of immature diseased pods; or to praedial larceny, though one would expect this to be more serious in less frequently harvested plots.

Weekly harvesting effected some reduction in the incidence of black-pod disease in Trial I and more beans were recovered from incompletely destroyed "black pods"; the differences in each case were small though statistically significant ($P = 0.05$).

Spraying treatments produced no significant effect on the overall incidence of the disease, but considerably reduced the number of "black pods" infected at the distal end. The comparisons are shown below, the number of distal infections being expressed as a percentage of the total "black pods" in each treatment.

	No spray	Bordeaux mixture	Perenox	Carbide-Bordeaux mixture
Bi-monthly application	50.6	42.7	42.1	35.4
Monthly application		33.8	39.0	29.2

The .../

The best treatment was Carbide-Bordeaux mixture applied every month. Sprays gave no reduction in "black pods" infected at the proximal end, most of which may originate through the fungus growing out from diseased cushions, a means of infection which fungicidal sprays cannot be expected to prevent. The layout of this trial has recently been altered to allow "spare" control plots to be used for experiments designed to show how many pods do become indirectly infected from cushions. The bi-monthly spraying treatment has now been replaced by a spray schedule based on the seasonal incidence of the disease, as assessed over the past two years.

TRIAL II

The figures for weekly and monthly harvesting treatments are comparable with those from Trial I; but there has been a lower incidence of disease and pest damage. There was little reduction in the number of "black pods" as a result of weekly harvesting, but only 11% of the entire crop was discarded because of the disease on weekly harvested plots compared with 19% on monthly harvested ones.

It is again apparent that the sprays (Perenox and Blitox) have not appreciably affected the overall incidence of black-pod disease. It is doubtful if the effect on distal infections alone can be assessed for this trial, as the figures reflect the lower general incidence of the disease and the small size of the experiment as compared with Trial I.

The only modification made to Trial II is the addition of wetting and spreading agents to the sprays.

(b) Spore Dispersal

Collation of data from the 176 recorded trees in the spore-trapping experiment on the First Progeny Trial Area (see 35th Quarterly Report) has not revealed any gradient of black-pod incidence from the central artificially induced source of high infection, although most "black pods" were recorded on trees which lay in the paths of two "prevailing" winds after passing through the central block. No spore trapping has been undertaken this quarter. More information on the factors governing spore release is necessary before continuing this line of approach to the dispersal problem.

(c) Cushion Infection

Many of the cushions labelled in the 1953/54 season, only a small proportion of which bore pods again this year, are now flowering and it appears that they may produce a better crop in the coming season.

Evidence has accumulated from the Fungicide Control Trials of a possible seasonal origin of pod infection from infected cushions during the period May to July. The number of pods infected at the proximal end at this time of year was very high, and remained so throughout August, when up to 90% of all "black pods" picked were of this type and distal infections were considerably reduced, doubtless due to the drier weather.

An .../

An attempt is being made to isolate the fungus from living cushions in situ, by surface sterilising them and affixing sterile tubes of molten nutrient medium, thereby inducing the fungus to grow out into the tube.

Assessment of Losses due to Black-Pod Disease in the Gold Coast

This project is included in the Research Programme for 1955/56. Records from the Department of Agriculture spraying sites and Cocoa Stations, taken during the last main-crop season by the Field Assistants trained last year, are now available, and it is hoped to assist the Department in summarising the data.

4. CAPSID STUDIES

(a) Capsid Pocket Regeneration Experiments

Several observation plots have been laid down at intervals since 1946 to study the regeneration of trees in capsid pockets by coppicing and by chemical control of capsids. The information obtained from these plots has now been summarised. It shows that although satisfactory regeneration may be achieved by coppicing and chemical control the results have been extremely variable, and the whole problem needs fuller experimental investigation.

It is proposed to lay down experiments to compare the relative value of :-

(a) protecting damaged trees with a residual insecticide;

(b) coppicing damaged trees and protecting subsequent growth with a residual insecticide;

(c) replanting.

The effect of tree age and initial severity of capsid damage on the response to treatments (a) and (b) will be examined, and it is hoped to study also the influence of shade and time of coppicing on treatment (b).

Persistence of Insecticides

The chemical control of capsids raises the general problem of the persistence of insecticides under tropical conditions, for in seeking to control an insect with successive overlapping generations it is essential to know for how long a particular insecticidal application retains its toxicity. A bioassay method is being used to study the persistence of DDT applied to cacao under field conditions. Our present inability to rear quantities of capsids under controlled conditions precludes their use as test insects. Pilot experiments using Tribolium castaneum Hbst. from standard cultures are being carried out. Later it is hoped to extend this work to include other persistent insecticides and formulations.

(b) Protection of Young Bearing Trees

The Spray-painting Trial at Nankese continues in the modified form described in the 36th Quarterly Report. An assessment of the results after eighteen months has been made.

All .../

All treatments appear to have given a high degree of control and differences between treatments are not statistically significant. Due, however, to the unavoidable absence of replication small differences cannot be detected.

The experiment to investigate possible damage to cacao by spray-painting is also continuing. After six treatments damage caused by 1.25% and 2.5% DDT as an aqueous emulsion is negligible, but it has become apparent in the 5% treatment.

(e) Attempted Simultaneous Control of Capsids and Calonectria

Experiments on the possibility of controlling capsids and Calonectria rigidiuscula (Berk. & Br.) Sacc. by means of a combined insecticide-fungicide spray have given anomalous results during the year, and it has not been possible to draw any valid conclusions.

(f) Ecological Studies on the Capsid Population

Routine Collections

In the Tafo area the populations of both Sahlbergella singularis Hagl. and Distantiella theobroma Dist. have declined during the quarter.

Intensive Observation Plots

The intensive fortnightly observations on the capsid population in two plots of one hundred mature cacao trees have now been carried out for one year. It has not been possible to relate population differences in the two plots to climatic differences between them. Nor has it been possible, as yet, to demonstrate significant relationships between population fluctuations and the various factors of the ecoclimate which have been measured.

Population Sampling

Following the arrival of mercury discharge lamps at the end of last year, light trapping was recommenced at the beginning of this quarter. A modified Robinson Trap incorporating a 500-watt mercury discharge lamp (which emits light rich in ultra-violet rays) has been used. The population estimates of S. singularis which have been obtained with the trap have not shown the decline apparent in the routine collections during the past three months.

Capsid Reproduction

Field and laboratory studies of capsid reproduction have been started, the primary objects being:-

(1) to investigate the effect of food supply on reproduction, and the extent to which seasonal changes in food supply may explain seasonal changes in capsid abundance;

(2) to see whether egg counts provide a satisfactory method for estimating capsid abundance.

Combined Cultural and Insecticidal Control

Treatments in the Dusting and Pruning Experiments, included in the 1955/56 Research Programme, have been continued.

An .../

An analysis of the numbers of capsid-damaged shoots removed during the past seven months from plots in the experiment on the Square Mile has suggested that the liquid treatment is more effective than the dusting treatment, and this applies to both pruned and unpruned cacao. However, this preliminary result cannot be considered conclusive as it has not been possible to demonstrate differences between the numbers of capsids found on plots undergoing the various treatments.

Insecticidal treatments were commenced in January on the second experiment in this series, which was laid down at Akwadum in August, 1954. The cacao - two-year-old Amazon - was not sufficiently advanced last August to take the dusting treatment; but pruning, where appropriate, has been carried out since that time.

5. EXPERIMENTS ON ESTABLISHMENT AND MAINTENANCE

(a) Establishment Trials

Results from these experiments have been examined during the quarter and the indications are as follows :-

(i) The use of basket seedlings of Amelonado cacao results in heavier bearing in the sixth and seventh years, but since overall yields are low it cannot be said that the increased yield would yet offset the extra cost of this type of planting material.

(ii) Judging from early yields, which were the same in each instance, the use of tree cassava and Gliricidia as temporary and semi-permanent shade does not adversely affect the establishment of Amelonado cacao compared with temporary shade, as provided in bush traverses, and permanent shade derived from forest saplings.

(iii) There is evidence that cacao may be established after food-crops (maize, cassava and plantains) but it is necessary to modify the local food-farming practices to such an extent in order to preserve the top-shade that the economic return from such food-farming is negligible. It appears that the presence or absence of adequate top-shade is an important factor in determining the percentage survival of Amelonado seedlings up to three years old.

(iv) Further proof has been obtained of the value of the best handling technique for bare-root seedlings. This involves the use of young seedlings grown in beds of easily worked soil, carefully removed from the beds at the time of transplanting without any reduction of foliage, and planted in freshly opened holes just large enough to contain their roots. Of some 4,000 seedlings planted out last year, using this method, only 203 have been lost to date, i.e. after the first dry season in the field. It is now believed that there is some value in using nursery beds that are composed of soil with a measure of water-retaining capacity, but a compromise between this and ease of removal from the beds must be sought.

There .../

There is no reason to suppose that the results of a transplanting trial are materially different when judged by plant survival counts made at the end of the first or second year.

(b) Spacing Trials

It has been possible to demonstrate that in the case of both young and mature Amelonado and young Upper Amazon cacao there is a decline in yield per tree with increasing stand density. In the case of young Amelonado there is a decline in yield per acre too. The importance of the effect with young Amazon cacao lies in the establishment of seed multiplication gardens, in which maximum productivity per mother seed available is obtainable by the use of wide spacings.

(d) Seedlings versus Rooted Cuttings

Consequent upon the heavy losses of cuttings reported in the previous quarter an examination of plants in the field and of the sites of vacant piquets was made, with a view to determining by subjective scoring if there was any degree of association between loss of plants and loss of vigour with shade conditions. The results indicated that there was in fact some association between heavy losses and very dense lateral shade.

(e) Effect of Soil Type on Pod Development and Yield

Yield data for 1951-55 have been summarised, and a persistent superiority of trees growing on soil of the Akwadum Series has been shown; unexpected because the Akwadum Series has always been referred to as a "bad" cacao soil. Even after removal of the tree-density factor the effect is still shown. Further analyses are required.

(f) Methods of Crop Forecasting

Data from 1951-54 have been summarised and analyses are being carried out by Mars Limited of Slough, England, whose generosity in this connection the Institute wishes to acknowledge. An additional approach by examination of the relationship between climatological data and monthly crop production is now being undertaken.

Frequency of Picking Experiments

Two experiments designed to compare the yields of trees, the pods from which are picked at 3-day, 6-day, 12-day, and 24-day intervals, have shown that in terms of pods per tree there is a significant decline in yield with increasing harvesting interval. The experiments (which were prompted by observations recorded in Section 3(a) - Fungicide Control Trials) will be continued during the coming crop.

6. SOIL FERTILITY AND MANURIAL REQUIREMENTS

(a) Experiments on the Effect of Major Nutrients

Little field work has been done this quarter. Analyses of leaves from two of the seedling fertilizer trials, at W.A.C.R.I. and Bunso, have shown significant absorption of fertilizer P at both sites and of fertilizer N at Bunso alone.

This .../

This suggests that the lack of response to fertilizers previously reported is not due to failure to absorb them.

To see if shade is responsible for the lack of response, it is being gradually removed from three of the six blocks on trials 5, 6 and 9A.

8. VEGETATIVE PROPAGATION

(b) Variation in Rooting of Single-Leaf Cuttings

The results of various experiments are summarised below:-

(i) The time-of-year at which cuttings were set affected to a considerable extent the number rooting from each clone, the main difference being between those set in the dry season and in the wet season.

(ii) The total number of cuttings rooted from R15 was greater than for either of the other two clones, TF1 and P30 (P = .01).

(iii) The number of roots per cutting was positively correlated with the number of cuttings which rooted on each occasion for the clones TF1 and P30 (P = .01).

(iv) The mean number of roots per cutting varied with the occasion of setting to a significant extent in TF1 (P = .01) and P30 (P = .05). The fall in the number of roots coincided with the onset of the dry season.

(v) The mechanical removal of a ring of tissue from the petioles of cuttings of P30 increased significantly the number of roots per cutting and the number of cuttings rooted, compared with "chemical ringing" and "no ringing" (P = .01 and P = .05 respectively).

9. PLANT BREEDING AND SELECTION

(a) Established Trials

Harvesting was completed during the quarter. The only outstanding advance in yield was from the two Clonal Trials. Selection R15 in the Second Clonal Trial, in its seventh year from planting, is now yielding in excess of 900 lbs. of dry cocoa per acre (computed).

The figures for pods borne on branches and on trunks show similarity; those for the Second P.T.A. are shown below :-

2ND P.T.A.

Trunk		Branches	
Healthy pods	Diseased pods	Healthy pods	Diseased pods
10,569	2,910	11,404	2,748

The .../

The incidence of swollen shoot disease in trial areas is reported on elsewhere.

(c) Comparative Growth and Yield Trials

Recording of tree height and girth has commenced in Series I Variety Trials. A full analysis will appear later, but it is evident that there are large differences in vigour between areas. The first ripe pods were recorded in the variety trial at Bunso.

A start has been made with the pollination programme for the nine Series II Variety Trials.

(g) Incompatibility

The study of populations containing self-compatible trees is being prepared for publication. An account of the first part of the incompatibility work appears in Heredity, 9, p.67, 1955.

(i) Polyploidy

Polyploids of Theobroma cacao and three related species have been intensively studied for differences from normal diploid T. cacao. A full account of this work is being prepared, with a view to publication.

10. COCOA FERMENTATION AND QUALITY

(b) Effect of Pod Ripeness and Storage on Cocoa Quality

A full report of this and other fermentation experiments and surveys is in course of preparation.

(d) A Survey of Fermentation Methods Employed by Cacao Farmers

In preparation for a survey during the coming season, contact has been made with the Agronomy Branch of the Department of Agriculture, with a view to the selection of a sample of farmers in the Eastern Region, and a questionnaire has been drawn up.

(e) Taste-Panel Studies

Three exploratory taste-panel trials have been held during the past year and the results have been examined during the quarter. As a result, it has been possible to further clarify ideas on the optimum mode of operation of local taste panels, and in particular to define a standard method of preparing the chocolate samples, which have been tested against "control" samples supplied by the United Kingdom Chocolate Industry. It is now clear that the most efficient means of operating local taste panels is by using a comparatively small panel of six tasters whose performance is known as the result of "Uniformity Trials" such as those recently carried out at W.A.C.R.I.

Bean Size of the Scavina (T12) Cacao

Although it was reported in the previous progress report that the bean size of this cacao type was not showing any improvement during the present crop year, examination of data which were not available at the time of writing that report has shown that, in fact, the beans are now approaching the desired 1gm. mean dry weight.

Beans .../

Beans smaller than this were noted only in September, January and February (0.97, 0.98 and 0.93 gm. respectively) and the average for the season was 0.99 gm. It is considered necessary to repeat the observations during the coming season in order to determine if this improvement is maintained or increased.

12. INSECTICIDE STUDIES

(a) Effect of Insecticides on Pollination

Cacao has now been dusted at three-weekly intervals with 5% DDT dust for over three years with no apparent effect on yield. The experiment continues.

(b) Systemic Insecticides

Inspections carried out on the experimental plot at Atukrom, in conjunction with Messrs. Pest Control Limited, have been discontinued.

13. ARBORICIDES

This experiment has now been completed.

All silk-cotton trees (Ceiba pentandra) have been killed by formulations of sodium arsenite, ammonium sulphamate (Ammate), oil containing 30% aromatic compounds, sodium chlorate, the iso-propyl and n-butyl esters of 2,4-D and 2,4,5-T, and mixtures of the last two.

Most trees of Cola gigantea var. glabrescens have been killed, but a complete kill was only obtained with formulations of sodium arsenite, the two above-mentioned esters, and some mixtures thereof.

In general, one to three years have elapsed between application and death. It has been confirmed that the great majority of poisoned trees disintegrate by degrees and so cause only slight damage to cacao growing beneath.

INVESTIGATION OF CACAO "SHADE"

This problem is item 13 in the 1955/56 Research Programme.

(a) Effect of Shade, Mulch and Fertilizers on Seedling Establishment

The factorial, N, P, mulch and watering trial started last quarter has now been analysed. A response to watering was obtained, as might be expected, but there were no other significant effects. The results suggest that drought was not the factor preventing response to fertilizer. The scope of the experiment has now been altered. Shade is being removed on two of the four blocks and the responses to N, P and mulching with and without shade will be investigated.

An NPK pot trial on Amazon seedlings was conducted in full sunlight and in artificial shade under a "plant barn". All plants were grown in shade until the first flush had hardened and the "unshaded" plants were then put into the open.

This .../

This transfer was later seen to have been a mistake; for two weeks afterwards the plants had made little growth and showed leaf scorch. Once they had become acclimatised to the new conditions, however, the unshaded plants did not differ in growth rate (as measured by leaf areas) from the shaded ones, and no more leaf scorch was seen. All plants were harvested 78 days after the start of the full-light treatment. No difference in response to fertilizers was observed between the shaded and unshaded plants.

A more detailed trial has been started using replicated and more precisely defined shade. To avoid the leaf-scorch of the preliminary experiment, all plants are being grown from the start under the light conditions which they will have to experience throughout their growth.

IBADAN SUB-STATION

1. VIRUS RESEARCH

(a) Host Range Investigations

The scope of the Adansonia digitata survey has been extended to the Northern Region, and trees with virus-like symptoms have been found near Funtua, which is in the Sudan-Savannah vegetation zone; but no positive "back-tests" have been obtained from them so far.

(c) Classification of Viruses and Virus Strains

Rate of Spread of Nigerian Isolates

The number of trees in the Offa Igbo Observation Plot which have shown symptoms has now risen to 198 out of 282: this represents a seven-fold increase over the number of infections originally observed eighteen months ago.

Effect on Yield and Growth

Yield recording of all trees in the Offa Igbo and Koroboto observation plots has continued.

Leaf measurements in an experiment on the effect of Nigerian isolates on the growth of seedlings have shown that eight of the nine isolates under investigation reduce leaf area considerably.

The ... /

The Effect of Nigerian Cacao-Virus Isolates on Growth of Seedlings Infected in the Bean Stage

Isolate	Leaf measurement ($cm.^2$) +					Mean	Standard error of the mean	Significantly different from healthy growth at P =
	Plant I	Plant II	Plant III	Plant IV	Plant V			
Asijere	30	36*	135	207	121	106	30	.001
Aladie	337	104	101*	146	-	172	48	.001
Iwo	286	250	328	287	408	311	26	.001
Olanla	316	404	297	289	350	331	20	.001
Ife	310	332	299	347	391	336	14	.001
Offa Igbo	436	326	471	489	486	441	29	.01
Ijaye	495	417	484	426	588	482	31	.01
Ilesha	736	548	398	665	350	540	66	.05
Elepo	677	633	1047	425	637	684	91	-
Healthy	690	1049	943	716	626	805	75	-

* Plant died.
+ These values are the sum of the products of leaf length and breadth for all leaves on each plant. They are proportional to the total leaf area.

(d) Attempted Mechanical Transmission of Cacao Viruses

Inhibition Studies

In the course of this work a strain of tobacco mosaic virus producing a systemic mosaic disease in a number of leguminous plants was isolated from cowpeas growing on Moor Plantation. This appears to be the first record of a tobacco mosaic virus producing a systemic disease in any legume, and the observation has been written up for publication.

Coppicing Experiments

This project is included in the Research Programme for 1954/55, as Section 1(i).

Observations made on the areas coppiced jointly by the Substation and the Cocoa Survey Division show that inspection of standing trees from ground-level does not reveal all the symptom-bearing trees in an outbreak, and that infected chupons may be produced from the stumps of trees which were symptomless when meticulously examined before and after felling.

Results from Coppicing Swollen-Shoot Outbreaks

Locality	Total number of trees coppiced	Number of infections diagnosed		
		Before felling	Additional	
			On felling	On regeneration
Egbu	832	8	*	19
Abudoro	1,132	12	*	-
Agunmu	39	13	*	6
INA Farm	274	20	4	7
Alagbe	764	70	11	6
Adifa	998	25	14	9+

* Inspection of felled trees not carried out in these experiments.
+ Symptom observation not yet complete.

The .../

The critical investigation of factors influencing regeneration after coppicing at I.N.A. Farm continues; regeneration and growth have been excellent over the whole of the twelve acres coppiced so far. Almost 90% of all the trees coppiced have regenerated, and are growing strongly. Observations based on over 1,600 trees indicate that there is a good chance of regeneration even when the trees are very severely damaged by capsid attack. Trees of all girth categories appear to regenerate equally well, though there are indications that chupons from stumps of older trees grow more quickly, probably because of their more extensive root-systems. Temporary shade, provided by palm leaves, over some of the stumps has not improved the early growth of chupons.

When trees were coppiced in the cool wet-season months fewer chupons developed from each stump, and they took longer to appear than when coppicing was done in the hot dry-season. It appears that temperature is an important factor, and it is interesting to note that during the cloudy periods at the height of the rains, maximum daily temperatures are usually below 83°F., a temperature given by Humphries (Ann. Bot., N.S., 8, p.260, 1954) as being critical for the bursting of cacao buds.

Chupons invariably seem to be produced on the flower cushions of the stumps, and a number have been found bearing spirally arranged flowers, indicating that chupons are formed by elongation of the flower-bearing axes, which normally remain rudimentary.

2. MEALYBUG STUDIES

(d) Biological Control : Nigerian Survey

Natural Enemies of Cacao Mealybugs

Field surveys of cacao mealybugs and their natural enemies in Nigeria were discontinued at the end of January. The results obtained in the survey of natural enemies are being written up for publication.

Identifications of many of the natural enemies have not yet been received from the specialists to whom specimens were sent; but Mr. Kerrich of the Commonwealth Institute of Entomology has reported that a series of parasites reared from Ferrisiana virgata (Ckll.) represents a species of Blepyrus, a genus not previously recorded by W.A.C.R.I. entomologists from West Africa.

Mealybug Cultures

This work comes under Section 2(f) of the 1954/55 Research Programme.

Colonies of Planococcus citri (Risso) and P. kenyae (Le.P.), established on cacao seedlings in screened cages, were attacked by predaceous Cecidomyiidae, which probably gained access through joints in the timbers of the cages round the doors. Colonies of both species have been re-established.

SKB.